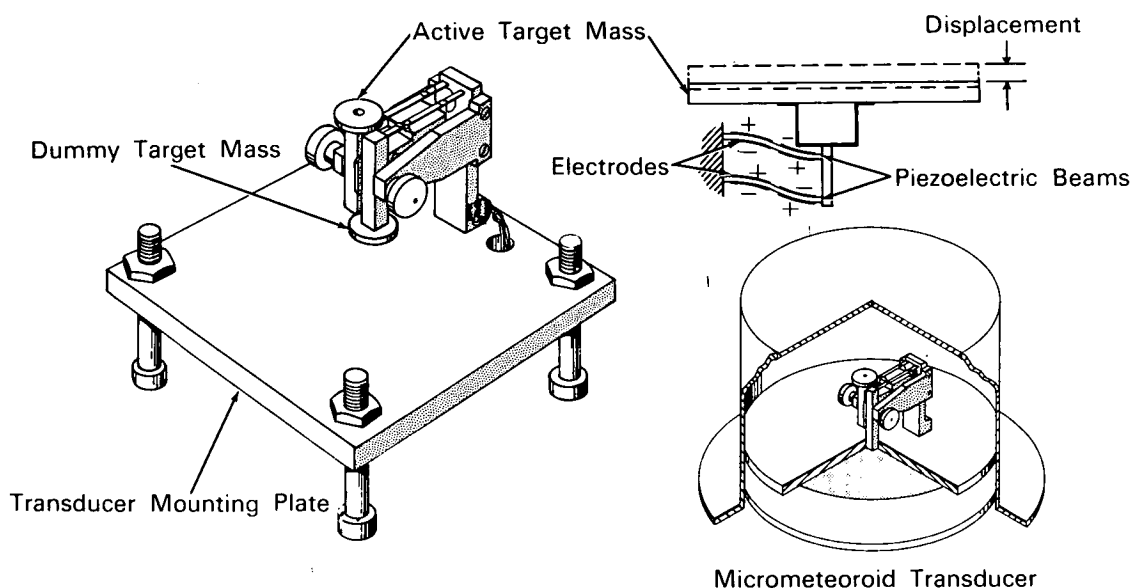


NASA TECH BRIEF



This NASA Tech Brief is issued by the Technology Utilization Division to acquaint industry with the technical content of an innovation derived from the NASA space program.

Ultra-Sensitive Transducer Advances Micro-Measurement Range



The problem: Development of an extremely sensitive impact-measurement device to measure the impact of micrometeoroids against a space vehicle. Currently available transducer and measurement devices either lacked the required sensitivity or had other limitations which restricted their utility.

The solution: An ultra-sensitive piezoelectric transducer that converts minute mechanical forces into electrical impulses. The instrument is so sensitive that it advances the state-of-the-art in micromasurement of forces and thus appears to have numerous research and development applications. It employs two parallel piezoelectric beams which support a target and act as momentum detectors. Sensitivity is equal to a target

deflection of two Angstroms (0.01 microinches) or to a momentum of 10^{-5} dyne-seconds. This is approximately equal to 1/1,000 of the momentum developed by a grain of salt weighing 150×10^{-6} grams when it is dropped one centimeter.

How it's done: Two piezoelectric ceramic beams are cantilevered parallel to each other from a rigid member and connected together at the free end which also supports a target. An impact or force on the target causes deflection of this cantilever assembly. By the piezoelectric effect, positive and negative charges are produced on the stressed beams. Electrodes on the surfaces of the beams serve to collect the positive and the negative charges and the voltage between them is proportional to the impact momentum.

(continued overleaf)

Although the instrument is of the dynamic type, it can be used for measuring a steady force, i.e. light beams, electron beams, or ion beams, by interrupting or chopping the beam so as to induce the natural resonance of the transducer.

A noise rejection device to eliminate unwanted signals created by acceleration or vibration is provided. This is accomplished by the addition of a dummy unit, possessing identical dynamic and electrical characteristics to those of the active sensing unit but connected 180 degrees out of phase. Tests indicate a rejection ratio of 400 to 1 for steady state, random, or impact type vibrations.

A calibration system based on the absolute electrometer principle is an integral part of the instrument. A DC potential is applied to a fixed plate which produces a force on an opposite plate attached to the spring-mass sensing system. On discharge of the potential, the system will oscillate, causing an output voltage from the flexed piezoelectric beam. This output voltage is calibrated to that produced by the impact of a body with known momentum.

A number of advantages of the ultra-sensitive instrument have been disclosed in recent tests. The piezoelectric transducer can withstand high G loads, can be caged to take shock loads, has uniform sensitivity over its entire target area and has a high degree of stability. Cost is modest and only normal support instrumentation is needed. Piezoelectric beams are made from a ceramic element often sold as a pickup unit for phonographs. A complete transducer unit weighs 200 grams and requires 150 milliwatts of power.

Notes:

1. Tests have shown that the transducer can accurately measure the heartbeat of an avian embryo inside an eggshell. Successful measurements have been made with eggs weighing as little as 7 grams. The embryo is not damaged or stimulated in any way during such measurements and the process is as simple as weighing the egg.
2. Its high sensitivity and wide range make this instrument an excellent device for calibration of laser beams.
3. Immediate industrial applications include vibration detectors, accelerometers, calibration of small jets and seismometers
4. A more detailed description of the piezoelectric momentum detector is presented in NASA SP-5007, "Measurement of the Heartbeat of Bird Embryos with a Micrometeorite Transducer" by Vernon L. Rogallo, April 1964, available from the Department of Commerce, Office of Technical Services, Washington, D.C. 20230. Inquiries may also be directed to:
Technology Utilization Officer
Ames Research Center
Moffett Field
Mountain View, California
Reference: B64-10004

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining royalty-free rights for its commercial use may be made to NASA Headquarters, Washington, D.C., 20546.

Source: Vernon L. Rogallo
(ARC-26)